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(54) Abstract Title

Etching polysilicon films

(57) A method for etching polysilicon comprises the steps of: a) supplying a wafer 22 having a polysilicon film into a process chamber 18; b) adjusting the pressure and the temperature of the process chamber within predetermined ranges; and c) supplying an etch gas including NF_3 or inter-halogen compounds into the process chamber to etch the polysilicon film. The etching apparatus comprises: an etch gas supply source 10 for supplying etch gas comprising NF_3 or inter-halogen compounds such as CLF_3 , BrF_5 , IF_3 , CLF , BrF_3 , IF_5 and BrF , a heating block 16 for controlling the temperature of the process chamber and a high vacuum pump 24 for controlling the pressure in the process chamber. The etch gas is mixed with a carrier gas such as N_2 or Ar from a source 12 and supplied via a diffuser 14 to the process chamber.

FIG. 1

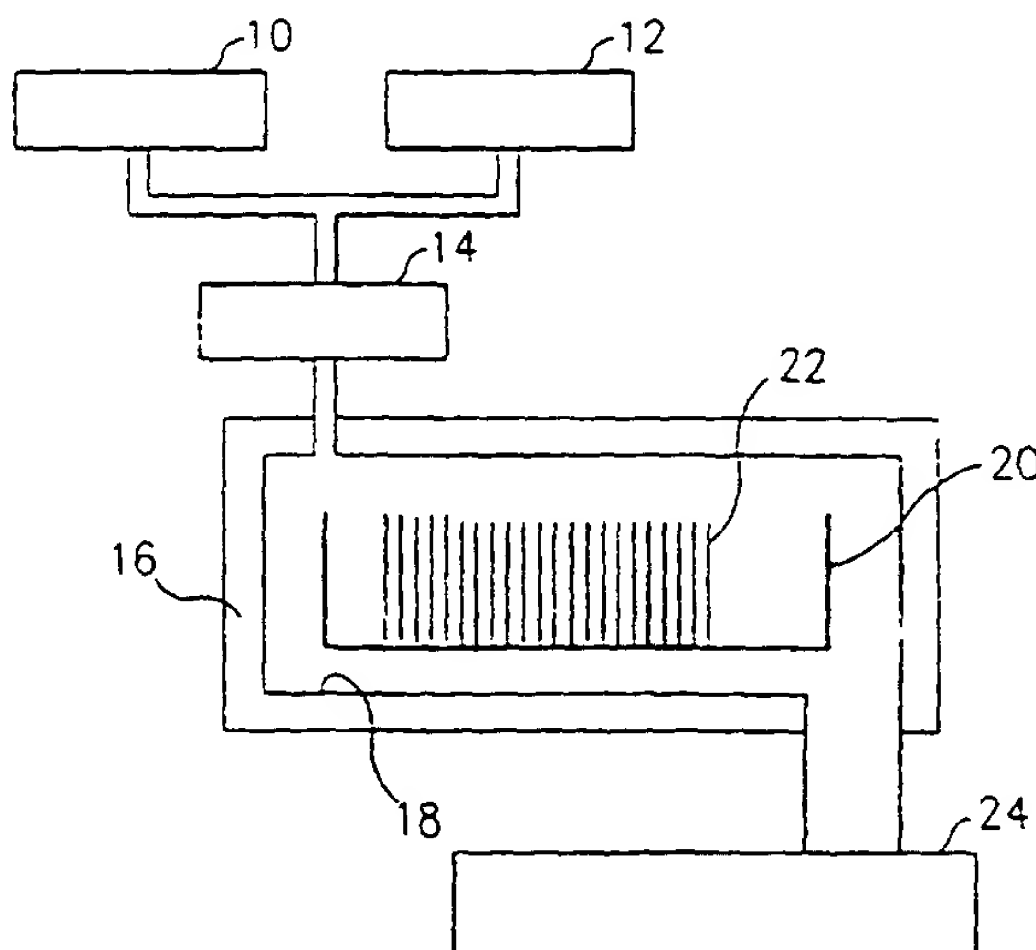


FIG. 1

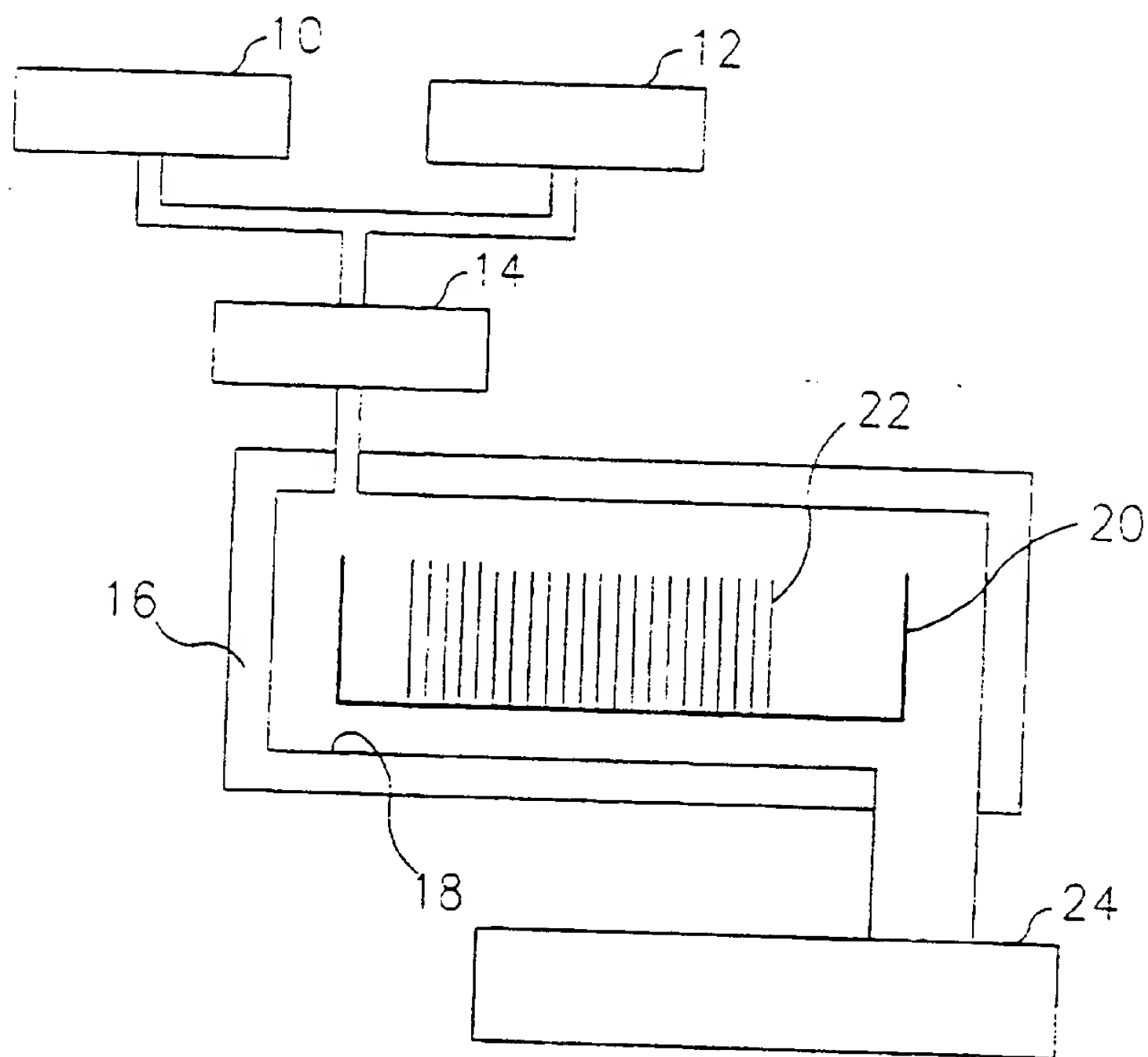


FIG. 2

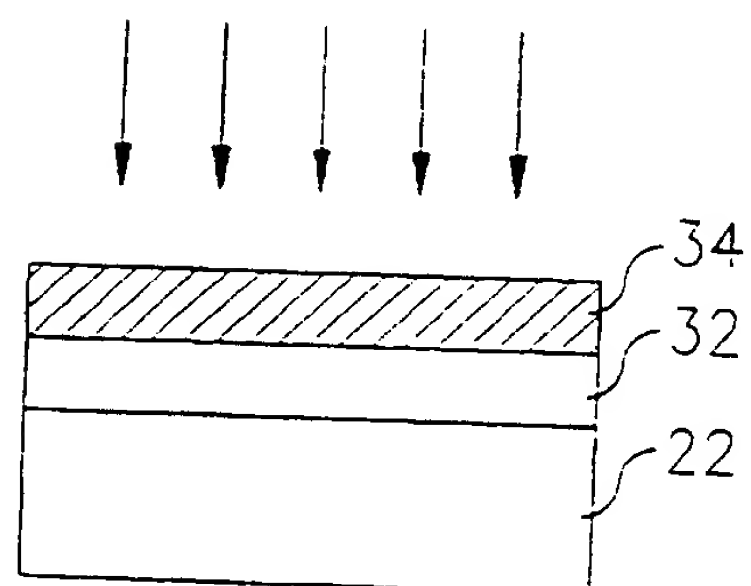
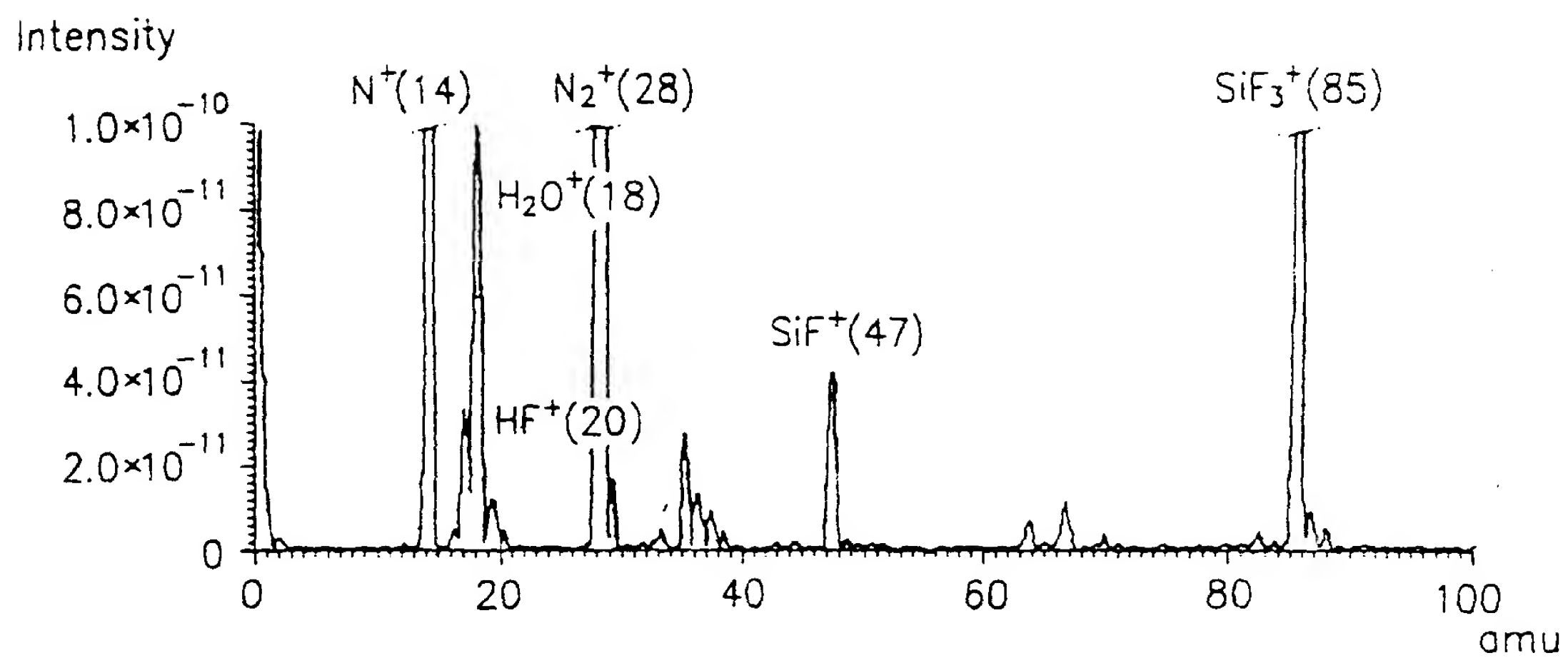


FIG. 3



POLYSILICON ETCHING METHOD AND ETCHING APPARATUS

Field of the Invention

The present invention relates to an etching method of polysilicon and its etching method, and more particularly, to a method for isotropic-etching a polysilicon film formed on a specific layer without the generation of plasma, and its etching apparatus.

Description of the Related Art

With the development of the semiconductor industries, and high-integration, high-capacitance, and high-performance of semiconductor devices, it requires the concentration of the increased number of devices on a limited area.

Accordingly, the wafering technology is more developed such that the pattern can be manufactured less than μm , and a dry-etch technology is commonly used in the wafer fabrication process in order to make highly-integrated and highly-sophisticated semiconductor devices. Commonly-used dry-etch technology employs plasma.

The dry-etch method using plasma is very important and difficult technology. The important elements which

should be considered in the plasma etch process are an etch profile, selectivity for sub-layers, etch rate, and uniformity, etc. These are mostly affected by etch apparatus, or the properties of supply gases.

5 When etching a layer of a silicon-bearing material by the plasma dry-etch, halogen compound containing fluorine (F) and chlorine (Cl) is supplied as etch gas. In addition, other kinds of gases can be added to the above etch gas and supplied for the improvement of the etch profile of the layer properties, and the selectivity
10 or as carrier gas.

 Each of the mixed gases does its own function, that is, the inert gases having a high mass such as helium (He), Argon (Ar) help to carry the etch gas as carrier
15 gas, and etches the layers by physical sputtering.

 The plasma dry etch method is divided according to the types of the plasma formation, into an Inductively Coupled Plasma (ICP) type, wherein plasma is formed magnetically by high voltage-applied coils around a
20 quartz tube for the plasma etch process ; and a Capacitively Coupled Plasma (CCP) type, wherein plasma is formed using high-frequency signal applied anode electrode and cathode electrode. However, the CCP type and the ICP type need supplementary devices such as
25 plasma source power, phase matcher, bias power, etc. such that element, radical, ions, etc. are present together with plasma state from the supplied reaction gases.

Therefore, it is necessary to develop a new method to carry out dry-etch process using reaction gas without the generation of plasma.

Summary of the Invention

5 The present invention is directed to provide a polysilicon etching method and an etching apparatus therefor for isotropic-etching a polysilicon film by the process environment inside a process chamber in which a process gas is supplied, such as the inner pressure,
10 temperature.

 To achieve these and other advantages and in accordance with the purpose of the present invention, an etching method for polysilicon comprises the steps of : a) supplying a wafer having a polysilicon film on a
15 certain layer into a process chamber ; b) adjusting the pressure and the temperature of the process chamber within predetermined ranges ; and c) supplying an etch gas including halogen compounds into the process chamber and etching the polysilicon film.

20 The certain layer may be an oxide film.

 The pressure inside the process chamber is in the range of from 0.5 to 3 Torr, and the temperature of the process chamber is above a boiling point of the etch gas below 800 °C.

25 The etch gas comprising halogen compounds is formed

by the combination of different kinds of periodic elements in the periodic table.

The etch gas may be a gas selected from ClF_3 , BrF_3 , IF_3 , ClF , BrF , IF , and BrF gases.

5 In addition, the etch gas may be NF_3 .

A carrier gas is supplied into the process chamber, and the carrier gas is preferably N_2 gas or Ar gas.

100 to 1000 SCCM of etch gas and 300 to 4000 SCCM of carrier gas are supplied into the process chamber.

10 In another aspect of the present invention, an etching apparatus for polysilicon according to the present invention comprises : an etch gas supply source for supplying etch gas comprising halogen compounds formed by the combination of different periodic elements
15 in the periodic table or NF_3 gas ; a process chamber connected to the etch gas supply source and having a temperature control means ; and a high vacuum line connected to the process chamber for controlling the pressure state of the process chamber.

20 A carrier gas supply source for supplying a carrier gas is connected to the process chamber.

In addition, the etch gas supply source and the carrier gas supply source are connected with a diffuser, and the diffuser and the process chamber are connected.

25 The temperature control means may be a heating block provided outside the process chamber.

In addition, a hot coil or a lamp may be provided

inside the heating block.

In addition, a dry pump is connected to the high vacuum line.

5 The inside wall of the process chamber may be formed with aluminum compound in order to prevent the inner wall of the process chamber from being etched by etch gas.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are
10 intended to provide further explanation of the invention as claimed.

Brief Description of the Drawings

In the accompanying drawings :

Fig. 1 is a representation showing one embodiment of
15 the polysilicon etch apparatus according to the present invention ;

Fig. 2 is a cross-sectional view showing one embodiment of the polysilicon etch method according to the present invention ; and

20 Fig. 3 is a graphical representation showing the polysilicon etch method of the Fig. 2 according to the present invention.

Detailed Description of the Preferred Embodiments

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

As shown in Fig. 1, the polysilicon etching apparatus of the present invention comprises an etch gas supply source 10 for supplying halogen compound gas formed by the ion combination of the different kinds of elements in the periodic table and having low combination energy, and a NF_3 gas having a low boiling point, and a high reactivity at about 63 kcal/mol, the combination energy between N-F.

As etch gas, Cl_2 gas, halogen compound gas having a high combination energy formed by the covalent bond of the same periodic elements in the periodic table is excluded.

In other words, halogen gas such as ClF_3 , BrF_3 , IF_3 , ClF , BrF , IF , and BrF having a low combination energy formed by the ion-bond can be used. Especially, the melting point of the ClF_3 is about -76.3°C , and boiling point is about 11.7°C . At room temperature (about 18°C), it shows a low vapour pressure, and the bond energy between Cl-F is 61.4 kcal/mol, which is unstable because of the low bond energy compared with the other etch gas such as CF_4 .

In addition, a carrier gas supply source 12 for supplying a carrier gas for carrying the etch gas such as N_2 or Ar gas.

In addition, a diffuser 14 is installed in the etch gas supply source 10 and the carrier gas supply source 12 for mixing the supplied gases easily respectively.

In addition, the diffuser 14 is connected to the process chamber 18 having a boat 20 with loaded with multi wafers 22. On the upper side of the wafer, as shown in Fig. 2, an oxide film 32 and a polysilicon film 34 are sequentially formed, and not in the drawings, photoresist pattern is formed on the polysilicon film 34.

The inner wall of the process chamber 18 is formed of aluminum material.

Outside the process chamber 18, there is provided a heating block 16 having a hot coil or a lamp for raising the temperature of the process chamber 18.

A high vacuum pump 24 such as a dry pump and the process chamber 18 are connected.

Therefore, with the operation of the high vacuum pump 24 such as a dry pump, the pressure of the process chamber 18 is maintained at 0.5 to 3 Torr, and with the application of a certain power on a hot coil installed in the heating block 16 or the operation of the lamp, the inner temperature of the process chamber 18 is maintained over 800 °C, a boiling point of the etch gas.

Among the halogen gas such as ClF_3 , BrF_5 , IF_3 , ClF , BrF_3 , IF_5 , and BrF , etc., the selected etch gas comes out of the etch gas supply source 10, and is supplied into the diffuser 14, and the carrier gas such as N_2 comes out

of the carrier gas supply source 12, and is supplied into the diffuser 14.

The etch gas and the carrier gas supplied into the diffuser 14 are mixed and supplied into the process chamber 18. At this time, the etch gas is supplied into the process chamber 18 at a flow rate of 100 to 1000 SCCM (Standard Cubic Centimeter Minute), and the carrier gas is supplied into the process chamber at a flow rate of 300 to 4000 SCCM.

Accordingly, the etch gas is converted into radical state by the temperature and the pressure inside the process chamber 18, and the etch gas in the radical state isotropically etches a certain portion of the wafer 22. Normally, the etch gas in the radical state has isotropic etch properties, and the etch gas in the ion state is anisotropic properties.

In addition, when the isotropic etch using the etch gas is carried out, the inner wall of the process chamber 18 is made of aluminum compound so that the etch of the inner wall of the process chamber 18 by the etch gas is prevented.

After that, analyzing the gas remaining inside the process chamber 18 using a Residual Gas Analyzer (RGA) for the spectrum showing the intensity of the electron corresponding to the mass of the element after ionizing the supplied gases, and the result is shown in Fig. 3.

Referring to the Fig. 3, from the presence of the

SiF₃· and the SiF₃·, the silicon of the polysilicon film 34 formed on the wafer 22 and the F of the etch gas of ClF₃ are chemically reacted so as to form SiF_x, SiCl_x, etc. From the N⁺ and N₂⁺, N₂ gas is used as carrier gas.

As other embodiment, the inner temperature of the process chamber is changed, and the other processing condition is maintained as same, and as shown in Fig. 2, an oxide film 32 and a polysilicon film 34 are sequentially formed on a wafer 22, and not in the drawings, the photoresist pattern on the polysilicon film 34 on the wafer 22 is etched for a certain time. The result is shown in the following table.

[Table 1]

temperature	400°C	500°C	600°C	700°C	800°C
polysilicon	1,000	1,800	3,000	5,700	9,500
film	(Å/min)	(Å/min)	(Å/min)	(Å/min)	(Å/min)
oxide film	--	20Å/min	30Å/min	60Å/min	140Å/min

Referring to the Table 1, when the inner temperature is maintained at 400 °C, the polysilicon film is etched at a rate of 1000 Å/min, and the oxide film is not etched.

When the inner temperature is maintained at 500 °C, the polysilicon film is etched at a rate of 1800 Å/min, and the oxide film is etched at a rate of 20 Å/min.

When the inner temperature is maintained at 600 °C,

the polysilicon film is etched at a rate of 3000 Å/min,
and the oxide film is etched at a rate of 30 Å/min.

When the inner temperature is maintained at 700 °C,
the polysilicon film is etched at a rate of 5700 Å/min,
5 and the oxide film is etched at a rate of 60 Å/min.

When the inner temperature is maintained at 800 °C,
the polysilicon film is etched at a rate of 9500 Å/min,
and the oxide film is etched at a rate of 140 Å/min.

When the inner temperature is maintained at 400 to
10 800 °C, the selectivity of the polysilicon film for the
oxide film is above 20 ; 1, which is typically a required
ratio in the normal semiconductor etch process.

Therefore, according to the present invention,
polysilicon film is isotropically etched using halogen
15 compound gas formed by the combination of the elements
placed on other periodic line of the periodic table with
a low bond energy, and NF_3 gas.

It will be apparent to those skilled in the art that
various modifications and variations of the present
20 invention can be made without departing from the spirit
or scope of the invention. Thus, it is intended that the
present invention cover the modifications and variations
of this invention provided they come within the scope of
the appended claims and their equivalents.

What is claimed is :

1. An etching method for polysilicon comprising the steps of :

5 a) supplying a wafer having a polysilicon film on a certain layer into a process chamber ;

b) adjusting the pressure and the temperature of the process chamber within predetermined ranges ; and

10 c) supplying an etch gas including halogen compounds into the process chamber and etching the polysilicon film.

2. The etching method for polysilicon of the claim 1, wherein the certain layer is an oxide film.

15 3. The etching method for polysilicon of the claim 1, wherein the pressure inside the process chamber is in the range of from 0.5 to 3 Torr.

4. The etching method for polysilicon of the claim 3, wherein the temperature of the process chamber is above a boiling point of the etch gas below 800 °C.

20 5. The etching method for polysilicon of the claim 4, wherein the etch gas comprising halogen compounds is formed by the combination of different kinds of periodic elements in the periodic table.

6. The etching method for polysilicon of the claim 5, wherein the etch gas is ClF_3 gas.

7. The etching method for polysilicon of the claim 5, wherein the etch gas is selected from BrF_3 , IF_3 , ClF , BrF_3 , IF_3 , and BrF gases.

8. The etching method for polysilicon of the claim 1, wherein the etch gas is NF_3 .

9. The etching method for polysilicon of the claim 1, wherein a carrier gas is supplied into the process chamber.

10. The etching method for polysilicon of the claim 9, wherein the carrier gas is N_2 gas or Ar gas.

11. The etching method for polysilicon of the claim 10, wherein 100 to 1000 SCCM of etch gas and 300 to 4000 SCCM of carrier gas are supplied into the process chamber.

12. An etching apparatus for polysilicon comprising

:

an etch gas supply source for supplying etch gas comprising halogen compounds formed by the combination of different periodic elements in the periodic table or NF_3 ,

gas ;

a process chamber connected to the etch gas supply source and having a temperature control means ; and

5 a high vacuum line connected to the process chamber for controlling the pressure state of the process chamber.

10 13. The etching apparatus for polysilicon of the claim 12, wherein a carrier gas supply source for supplying a carrier gas is connected to the process chamber.

15 14. The etching apparatus for polysilicon of the claim 13, wherein the etch gas supply source and the carrier gas supply source are connected with a diffuser, and the diffuser and the process chamber are connected.

15. The etching apparatus for polysilicon of the claim 14, wherein the temperature control means is a heating block provided outside the process chamber.

20 16. The etching apparatus for polysilicon of the claim 15, wherein hot coil or a lamp is provided inside the heating block.

17. The etching apparatus for polysilicon of the claim 16, wherein a dry pump is connected to the high

vacuum line.

18. The etching apparatus for polysilicon of the claim 12, wherein the inside wall of the process chamber is formed with aluminum compound.

5 19. A etching method of polysilicon and etching apparatus, substantially as described herein with reference to and as illustrated in the accompanying drawings.



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Claims searched: All

Examiner: C.D.Stone
Date of search: 18 November 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:
UK Cl (Ed.P): H1K(KLECA,KLECX)
Int Cl (Ed.6): H01L
Other: ON LINE, W.P.I.

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	EP 0272143 A2 APPLIED MATERIALS	1
X	EP 0259572 A2 I.B.M.	1
X	US 3511727 MOTOROLA	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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